DOI 10.1007/s10891-017-1630-x
Journal of Engineering Physics and Thermophysics, Vol. 90, No. 4, July, 2017

MATHEMATICAL MODELS OF MASS TRANSFER PROCESSES IN SOILS WITH ACCOUNT FOR THEIR INTERACTION WITH RAINFALL

N. E. Galiullina and M. G. Khramchenkov UDC 532.546

Equations of physicochemical mechanics for swelling soils interacting with rainfall in the course of the process of surface discharge are obtained. The behavior of unsaturated swelling soils in anomalous conditions of surface discharge has been analyzed. A comparison with the data of normal conditions of the surface discharge regime has been carried out.

Keywords: *mass transfer, swelling soils, surface discharge, subsurface drainage.*

Introduction. The motion of waters on the earth's surface and in the earth's crust under gravity, constituting the most important link in the general circulation of water in nature, is called discharge or drainage. One distinguishes between the surface or river discharge and subsurface drainage, with the surface discharges being subdivided into a declivent one, when water flows off a slope, and a fluvial one, when water follows the stream- and river-courses [1].

The discharge from a patch of land is measured by:

1) the water flow rate, i.e., by the volume of water flowing per unit time through the so-called clear opening of a river,
2) the discharge modulus, which is understood to be the quantity of water in liters flowing down per unit time (usually per second) from one square kilometer of area,
3) the drainage coefficient showing the fraction of rainfall (in percent) that drains down into rivers.

The water draining into rivers washes down also loose rocks resulting from weathering. Moreover, the erosive (destructive) work of rivers also makes them suppliers of loose rocks. This process forms the so-called solid drainage, which is a mass of suspended substances transported by flow over the river bottom and dissolved in the river water. Their quantity depends on the energy of the moving water and on the resistance of the rocks to the erosion by water.

The magnitude of drainage depends on a number of factors:

1) the climate: the greater the amount of rainfall and smaller vaporability, the more is drained and vice versa. The amount drained depends on the type of precipitation and on its distribution in time;
2) the topography: when air masses rise uphill, they are cooled as on their way they meet with colder atmospheric layers, and the water vapor condenses; therefore, the quantity of precipitation increases;
3) the soil cover: in the zones of excessive wetting, most of the year the soil is saturated with water and gives it up to rivers. In the zones of insufficient wetting, in the season of snow thawing the soil is capable of imbibing all the thawed water; therefore the drainage in these zones is weak;
4) the vegetable cover: the investigations carried out in recent years in connection with the planting of windbreaks in steppes point to the positive influence of plants on draining, because it is more appreciable in forest zones than in steppe ones;
5) the influence of bogs: it is different in the zones of excessive and insufficient wetting. In the forest zone, the bogs are regulators of drainage, whereas in the forest–steppe zone their influence is negative — they absorb the surface and ground water and evaporate it into the atmosphere, thus violating both the surface discharge and subsurface drainage;
6) large running-water lakes: they function as a powerful regulator of drainage, but, true enough, act only locally.

From the foregoing brief review of the factors that influence drainage, it follows that its magnitude varies with time.

Institute of Mathematics and Mechanics of the Kazan Federal University, 18 Kremlevskaya Str., Kazan, 420008, Russia; email: mkhramch@gmail.com. Translated from Inzhenerno-Fizicheskii Zhurnal, Vol. 90, No. 4, pp. 862–870, July–August, 2017. Original article submitted January 18, 2016.